Eucalyptus wood for energy and the costs of carbon dioxide abatement in power and heat generation systems in Thailand

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Introduction

The growing concerns about global climate change and the awareness about the need to develop sustainable energy resources for the future have renewed interest in all renewable energy resources. A promising long-term solution to the energy and carbon emission problem is the replacement of fossil fuels by sustainably produced wood fuels [1]. However, at present, the fossil fuel based systems are more competitive and have an unfair advantage over biomass systems to the extent that they fail to internalize the environmental costs. In order to account for the negative externalities from fossil fuels, environmental taxes need to be imposed. In addition, Clean Development Mechanisms (CDM) of the Kyoto Protocol will have the potential to facilitate investment in the biomass-based systems in developing countries. In Thailand, in addition to agricultural and wood residues, eucalyptus plantations have been suggested to be a major potential source of biomass energy [2]. The paper starts by providing background information on the energy situation and biomass energy sources in Thailand. The paper explores the land area, supply, productivity and costs of eucalyptus plantations in Thailand which have been established mainly for pulpwood production where the calculation of the cost of eucalyptus production are based. In later sections, an economic analysis of power/heat generation based on eucalyptus wood fuel and fossil fuels such as coal, natural gas and fuel oil in Thailand is performed. The study considers the costs of electricity/heat generation of different technologies and compares the costs of CO2 abatement for different pairs of biomass and fossil fuel based systems.

Assumptions

As for power generation, the economic analysis here considers a generic representation of technologies. Three sizes of biomass technologies are considered; 100 kW, 1 MW and 50 MW. The coal and natural gas power technology is considered to be a 500 MW plant. As for heat generation, the analysis compares one size of heat generation technology (50 MW) based on biomass, coal and fuel oil. In this analysis, the base price of fuel is assumed to be 1.5 US/GJ for coal, 3 US/GJ for natural gas, 2.7 US/GJ for fuel oil [3]. The price of eucalyptus wood is presumed to be 2 US/GJ (price at factory gates for pulp production in 2001). The production costs of eucalyptus wood calculated and based on data of the production in the Northeast and East of Thailand where the largest plantations areas for pulpwood production have been established lie in the range of 1-1.5 US/GJ, which suggests reasonable profits for farmers. The capital costs are assumed to be scale dependent. The small sized plants having lower scale economy have higher unit capital cost. The range of capital costs for power and heat generation plants and the conversion efficiency are assumed based on reported costs [1, 4]. The annual operating hours are assumed to be 6,000 hours for a size plant of 50 and 500 MW but the those of a smaller sized plant are presumed to be lower. An annual rate of interest is assumed to be 10 percent. In order to estimate how much CO2 emissions from fossil fuel based systems can be abated through the use of biomass-based systems, assumptions on emissions factors of different fuels are used [4].

Results

At the fuel wood price of 2.0 US/ GJ, the electricity generation cost is 5.1, 6.2 and 8.1 cents/kWh for a 50 MW, 1 MW and 100 kW biomass plant, respectively. A comparison of electricity generation costs for different sizes of biomass plants and a 500 MW coal and natural gas plant shows that the generation cost for a large sized biomass plant is higher by 1 cent/kWh and 1.5 cent/kWh than that for a coal and natural gas plant, respectively. As the coal and natural gas are presumed to be available at the price of 1.5 US/GJ

and 3 US/GJ, respectively and the base price of biomass is presumed to be 2 US/GJ, the fuel cost for the biomass plant is higher by 0.6 and 0.24 cent/kWh. The capital cost of the biomass plant is higher by 0.35 and 1.2 cent/kWh due to the larger scale economy in the coal and natural gas plant. The smaller scale of a 100 kW biomass plant with a lower utilization rate results in a very high proportion of capital cost in the unit generation cost. Evidently, the small sized biomass plants cannot compete with the coal and natural gas plant even if biomass fuel is very cheap. However, the result shows that a large scale biomass plant (50 MW) has lower electricity costs than a coal and natural gas plant if biomass is available at a cost below 1.2 and 0.8 US/GJ. Therefore, a subsidy for the biomass power plant or tax imposed on coal and natural gas correponding to 28 and 80 US/ton C is required to make electricity from eucalyptus wood competitive with electricity from coal and natural gas. For heat generation, the result shows that the general cost is 1.64, 1.43 and 1.39 cents/kWh for a 50 MWth plant based on eucalyptus wood, coal and fuel oil, respectively. Heat generated from eucalyptus wood can be competitive with those from coal and fuel oil when the wood price is below 1.5 US/GJ. This corresponds to the cost of carbon abatement of 16 and 26 US/ton C for coal and fuel oil, respectively.

Conclusion

From this analysis, it is evident that under fair competition whereby an externality from fossil fuels is internalized, biomass electricity from eucalyptus wood can be quite competitive with conventional fossil fuel based power and heat plants. The results suggest that the costs of carbon abatement for heat generation systems based on coal and fuel oil are lower than those of electricity generation systems based on coal and natural gas. The cost of carbon abatement in a power and heat generation plant based on coal is estimated at 26 and 16 US/ton C, respectively. The low costs of carbon abatement in both systems suggest that there may be an interest for Annex 1 countries to invest in CO2 abatement projects based on eucalyptus wood production in Thailand. The analysis and the survey of the land area, supply, productivity and cost of eucalyptus plantations in Thailand also suggests a further investigation (to be done in a forthcoming paper) of the land area requirement from eucalyptus plantations area at present and in the future for power and heat generation plants based on eucalyptus wood and the potential to reduce the land requirement and the cost of eucalyptus production as well as the associated cost of carbon abatement such as by improving the productivity of eucalyptus production.

References

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